COMSOL® AIDED COIL DESIGN FOR NEUTRON SPIN TRANSPORT

Libertad Barrón-Palos
*Universidad Nacional Autónoma de México*
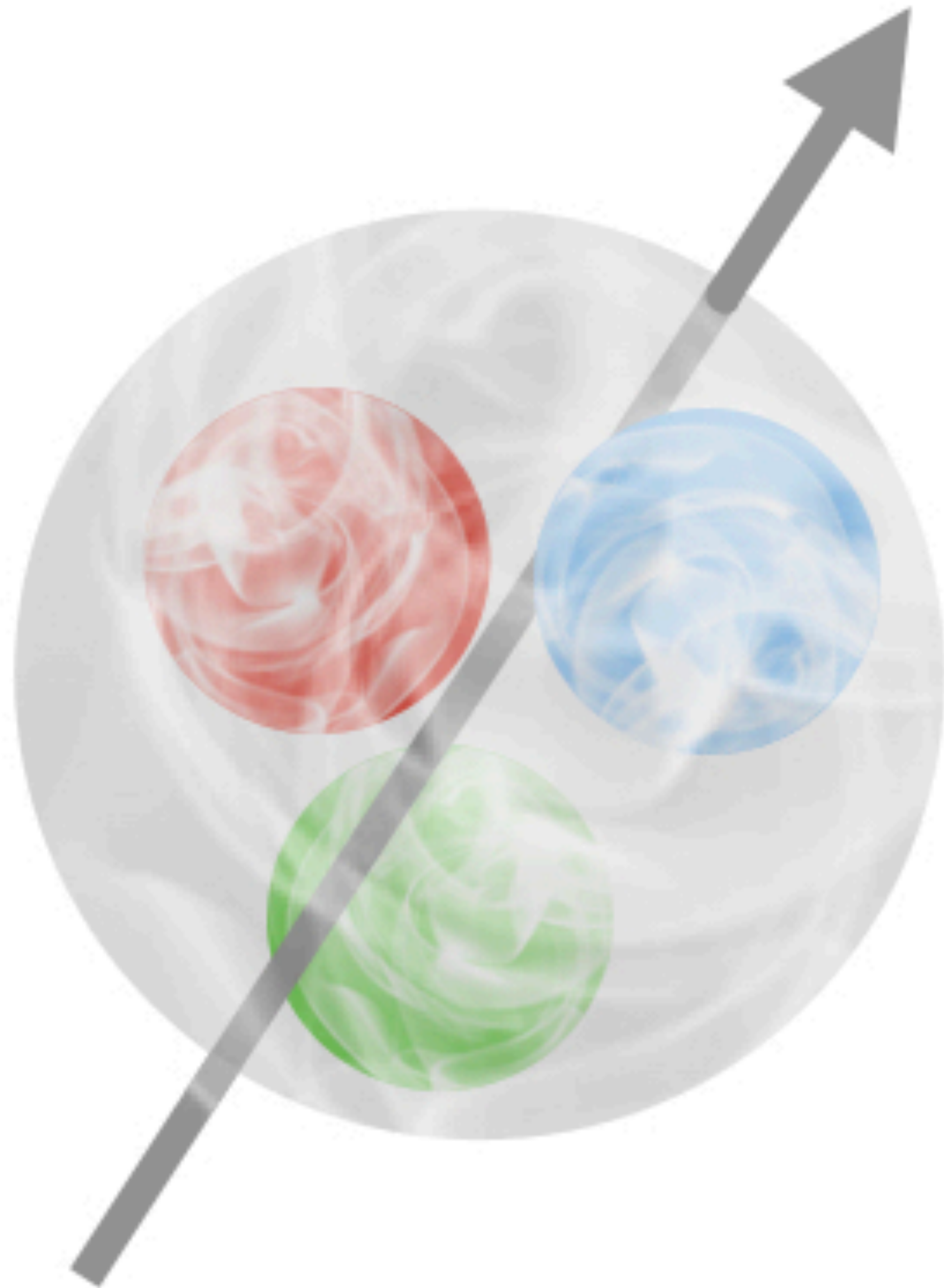
WITH POLARIZED LOW ENERGY NEUTRONS

➤ Study fundamental symmetries to understand interactions and to search for new physics

➤ Search for possible exotic forces that depend on the spin

➤ Contribute to understand the unbalance between matter and antimatter in the early universe

➤ Contribute to establish the nature of dark matter
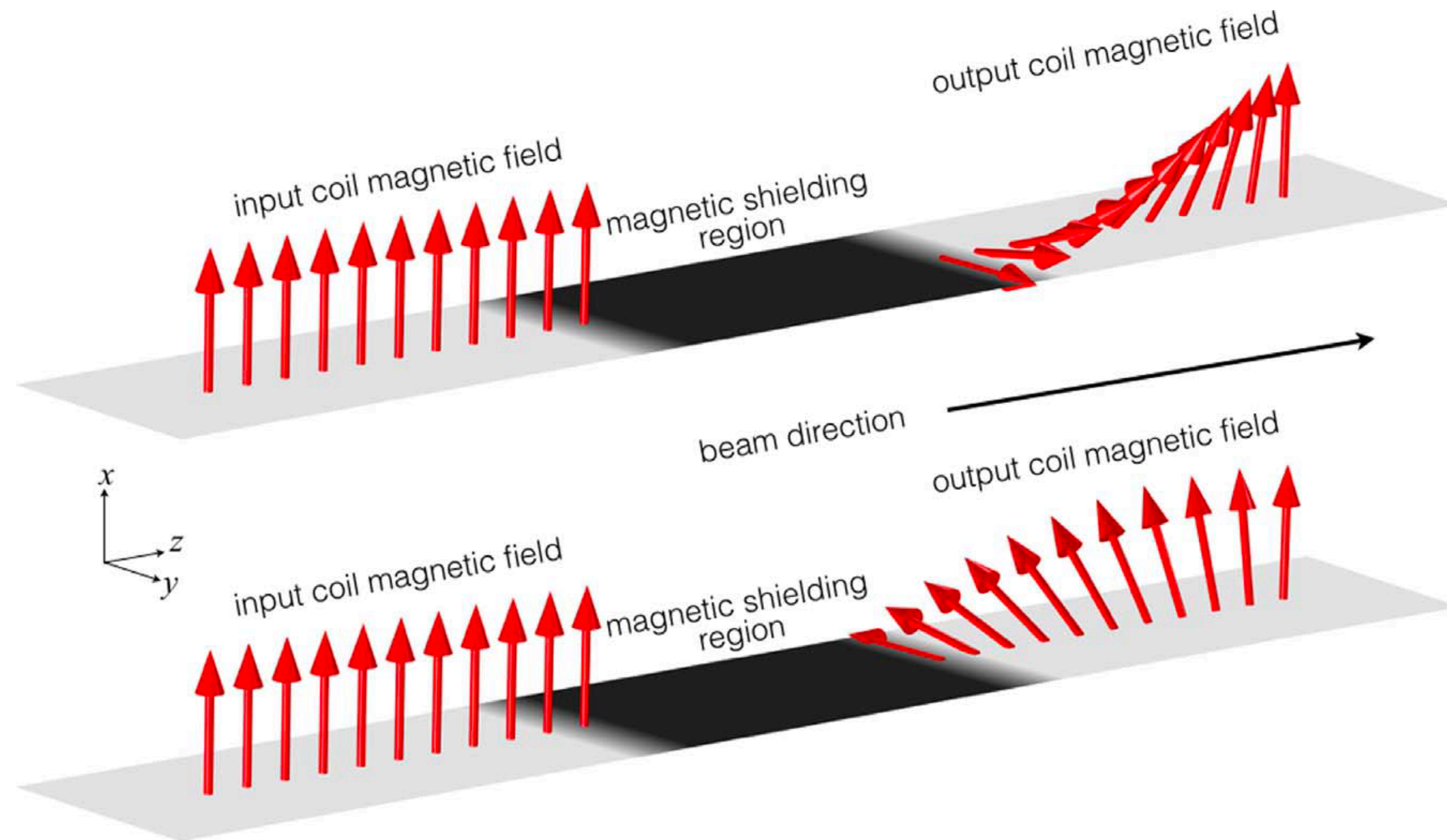
HOW CAN WE MANIPULATE NEUTRON SPIN?

$$s = \frac{\hbar}{2} \qquad \vec{\mu} = \gamma_n \, \vec{s}$$

$$\gamma_n = -1.83247171(43) \times 10^8$$
$$\text{rad s}^{-1} \, \text{T}^{-1}$$
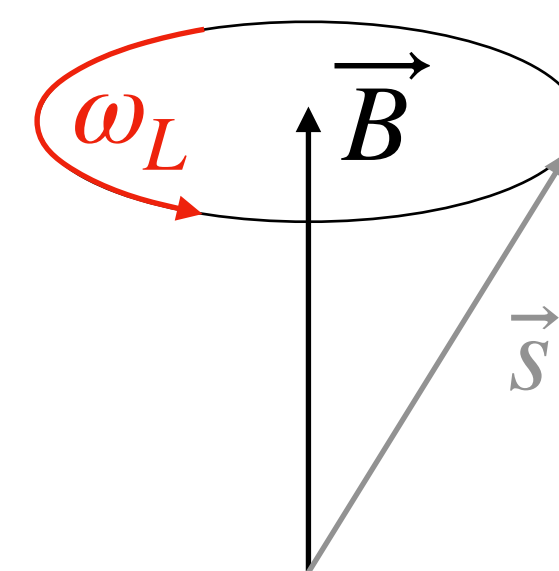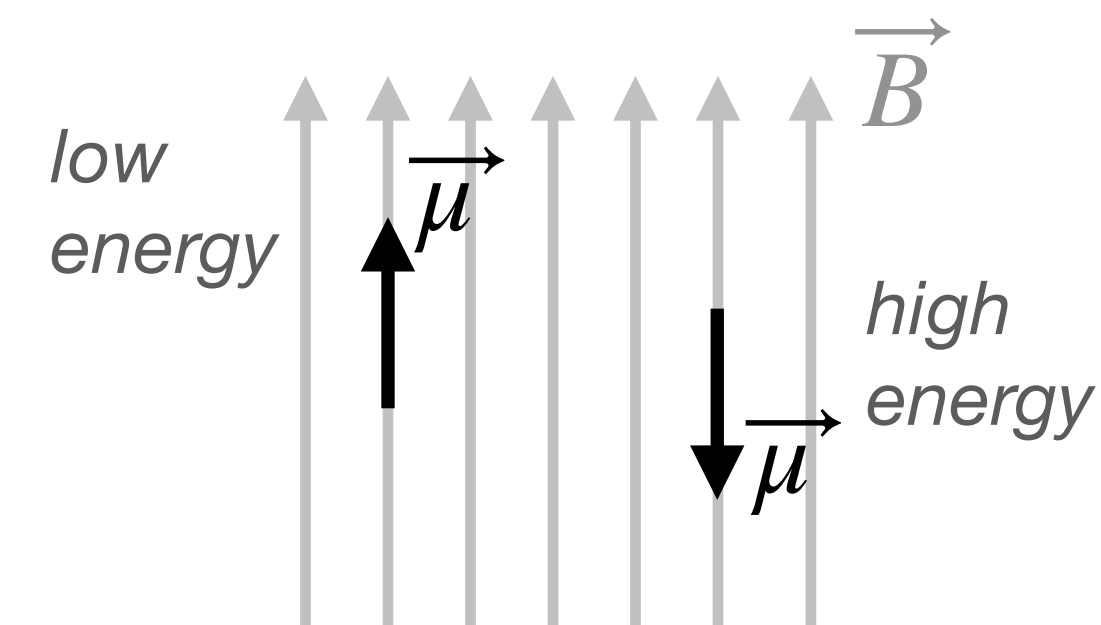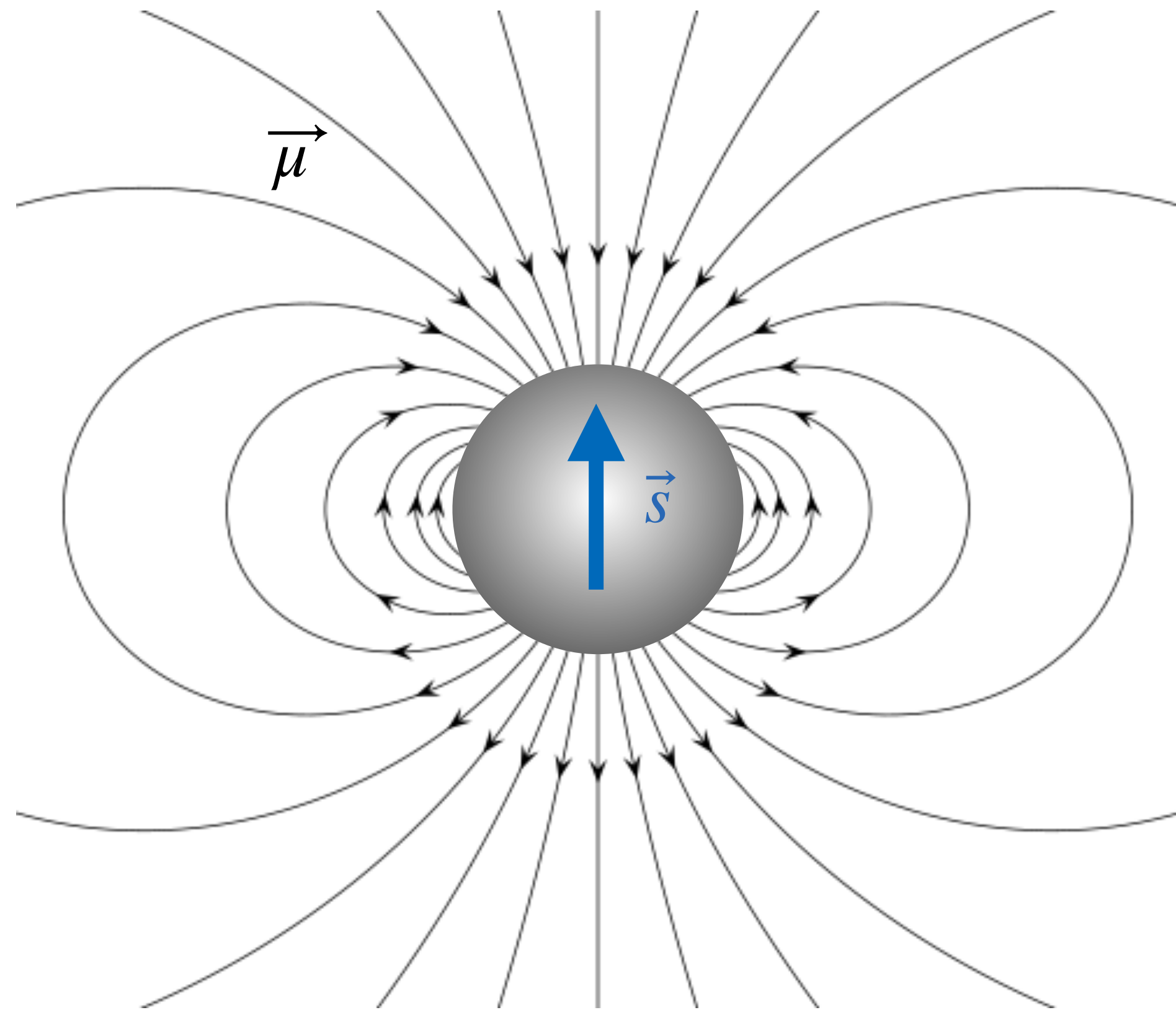
$$\vec{\tau} = \vec{\mu} \times \vec{B}$$
$$\omega_L = \gamma_n \, B$$

NEUTRON SPIN ROTATION STUDIES: AN EXAMPLE OF COIL DESIGN USING COMSOL®

Determination of very small neutron spin rotations

$$\left(\frac{d\phi}{dz} \approx 10^{-7} \text{ rad/m} \right)$$

To learn about

➤ Hadronic weak interaction (parity violation)

➤ Possible parity-odd long-range interactions

➤ Possible long-range spin-dependent interactions mediated by the exchange of exotic particles (dark matter candidates)

📄 W. M. Snow *et al.*, Phys. Rev. C 83, 022501(R) (2011).

📄 H. Yan and W. M. Snow, Phys. Rev. Lett. 110, 082003 (2013).

📄 C. Haddock *et al.*, Phys. Lett. B 783, 227-233 (2018).

COMSOL CONFERENCE 2020 NORTH AMERICA

THE MAGNETIC SCALAR POTENTIAL METHOD

In a region of space free of currents

$$\nabla \times \vec{H} = 0,$$

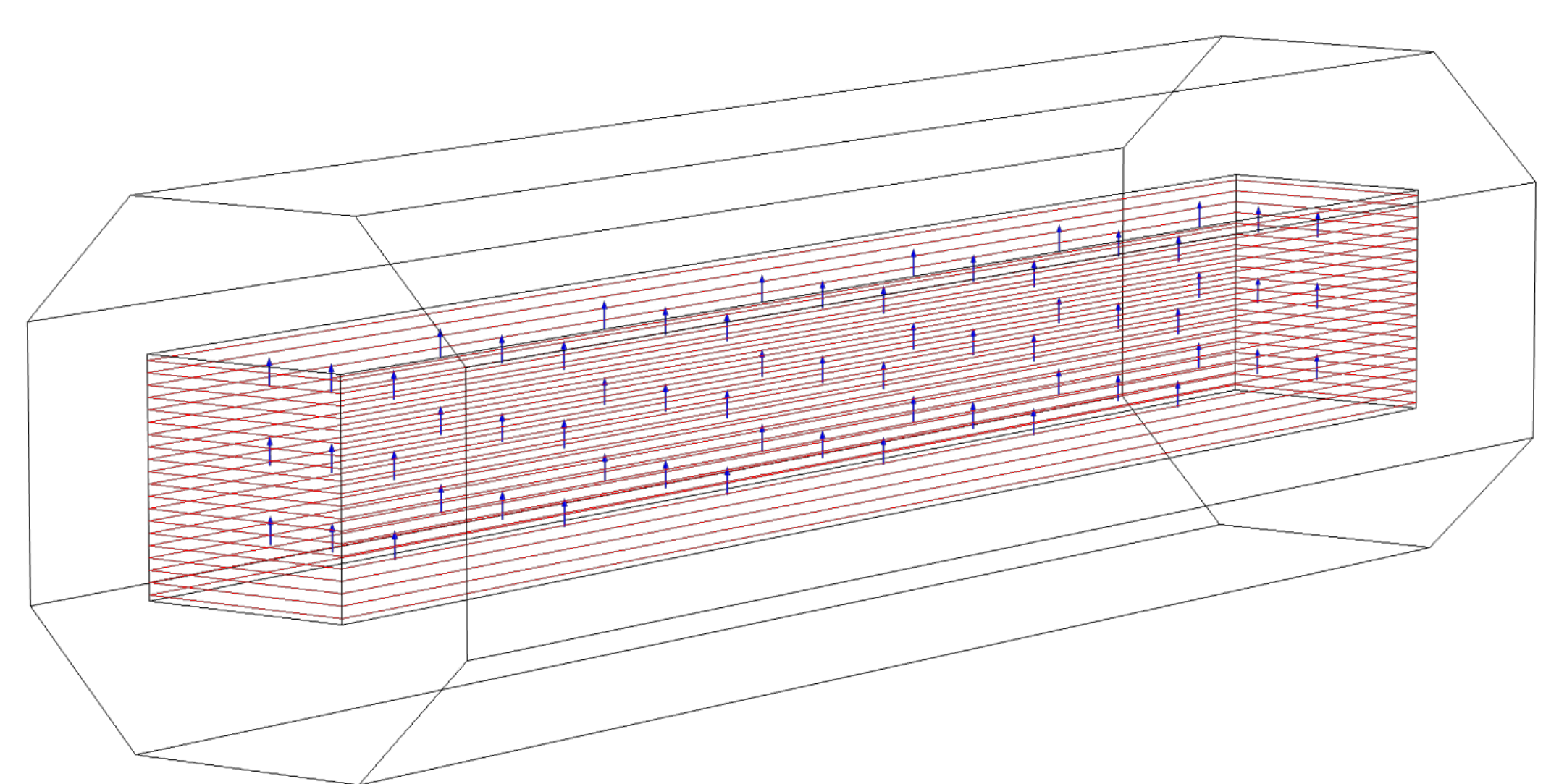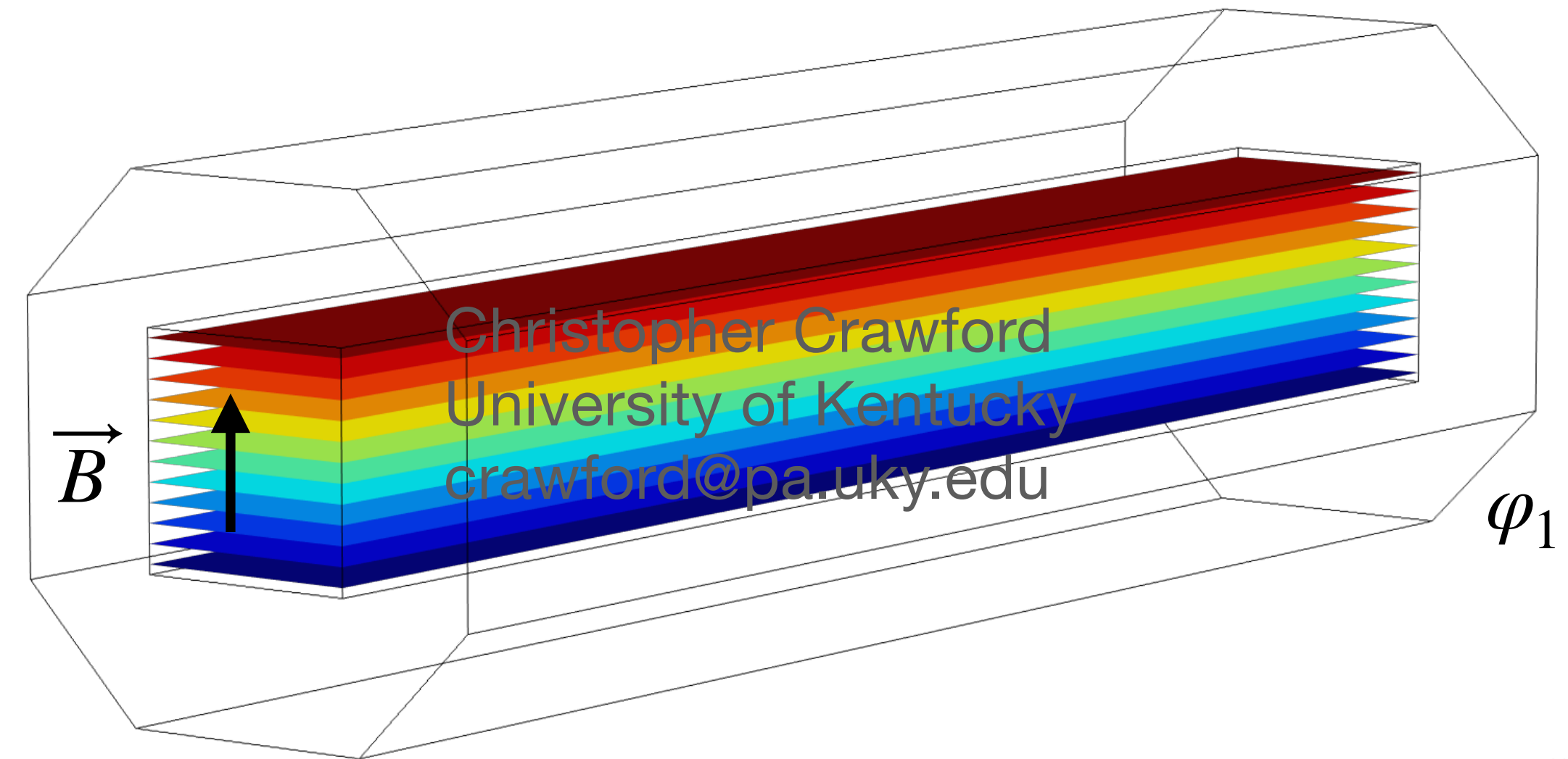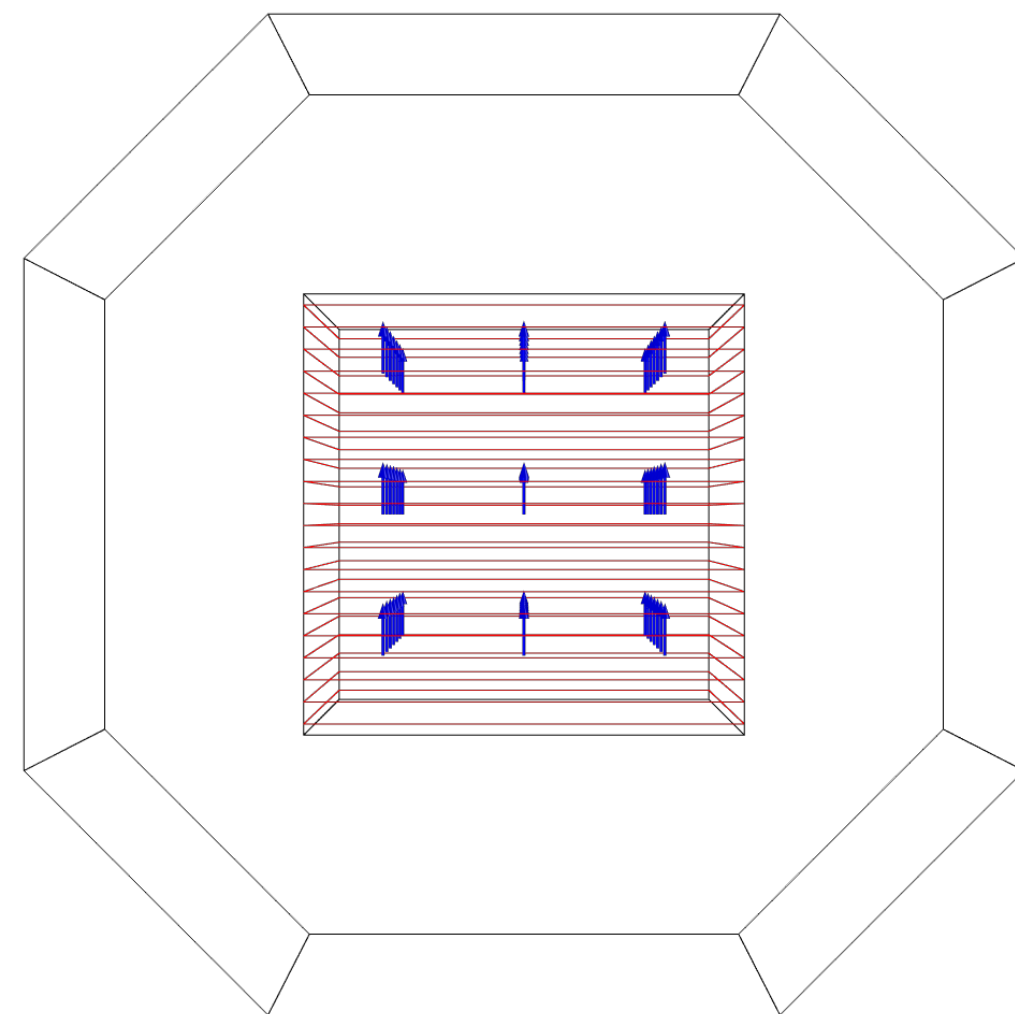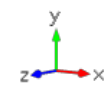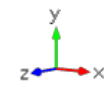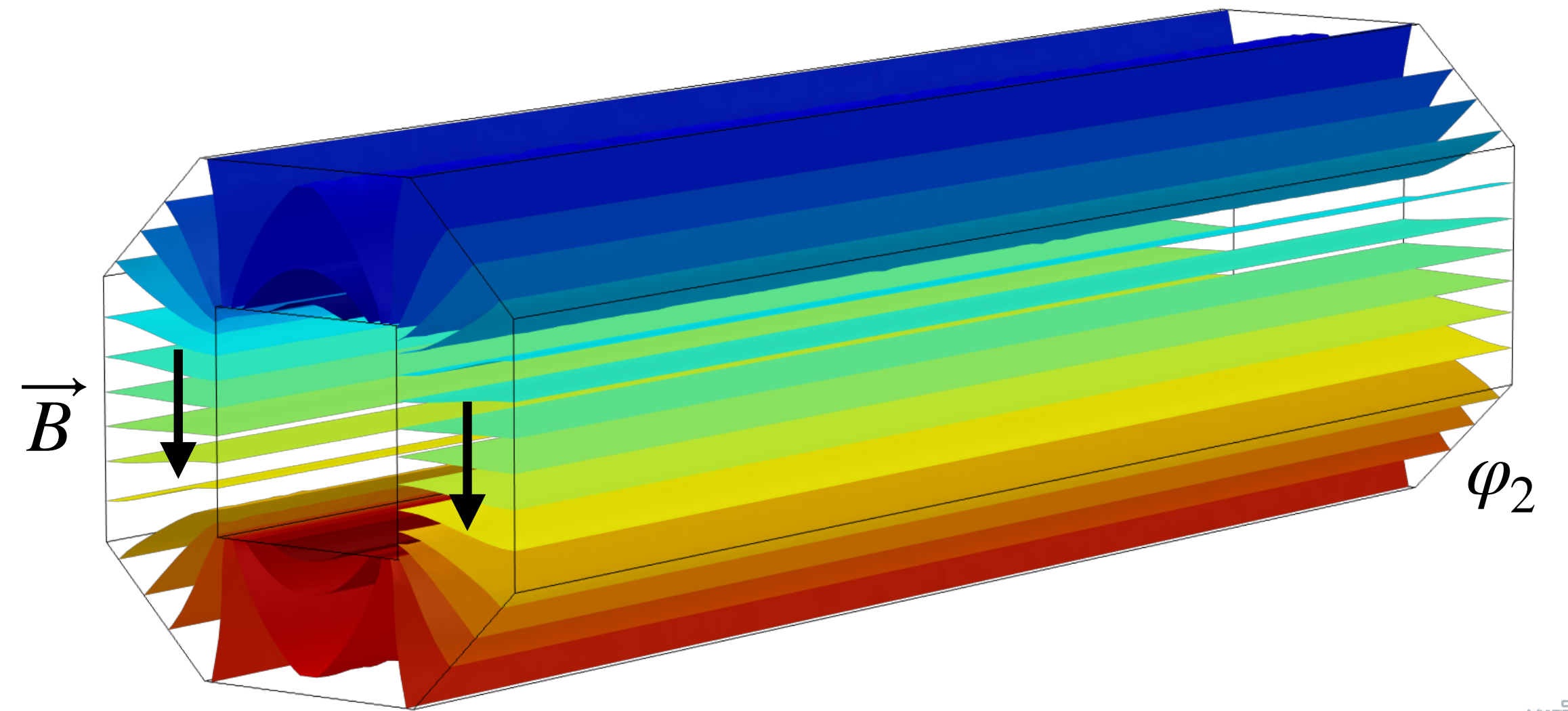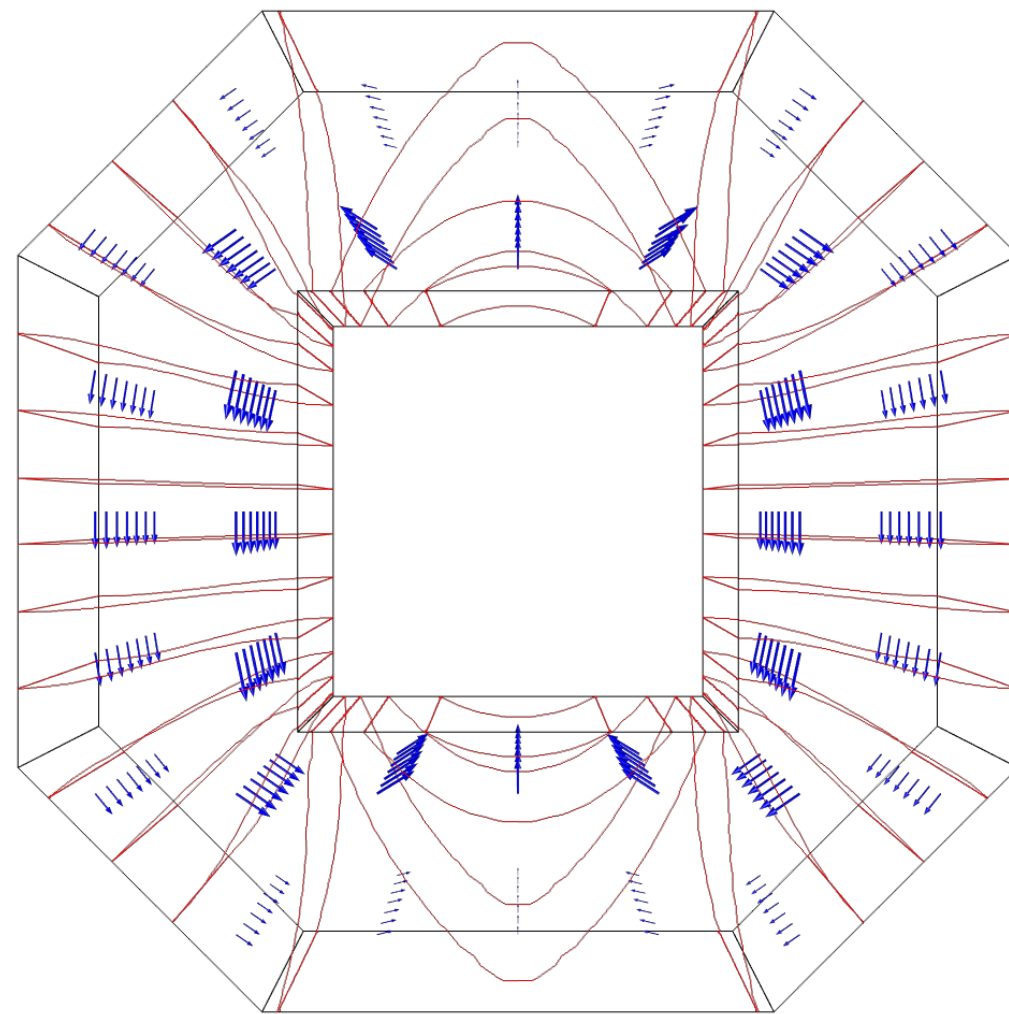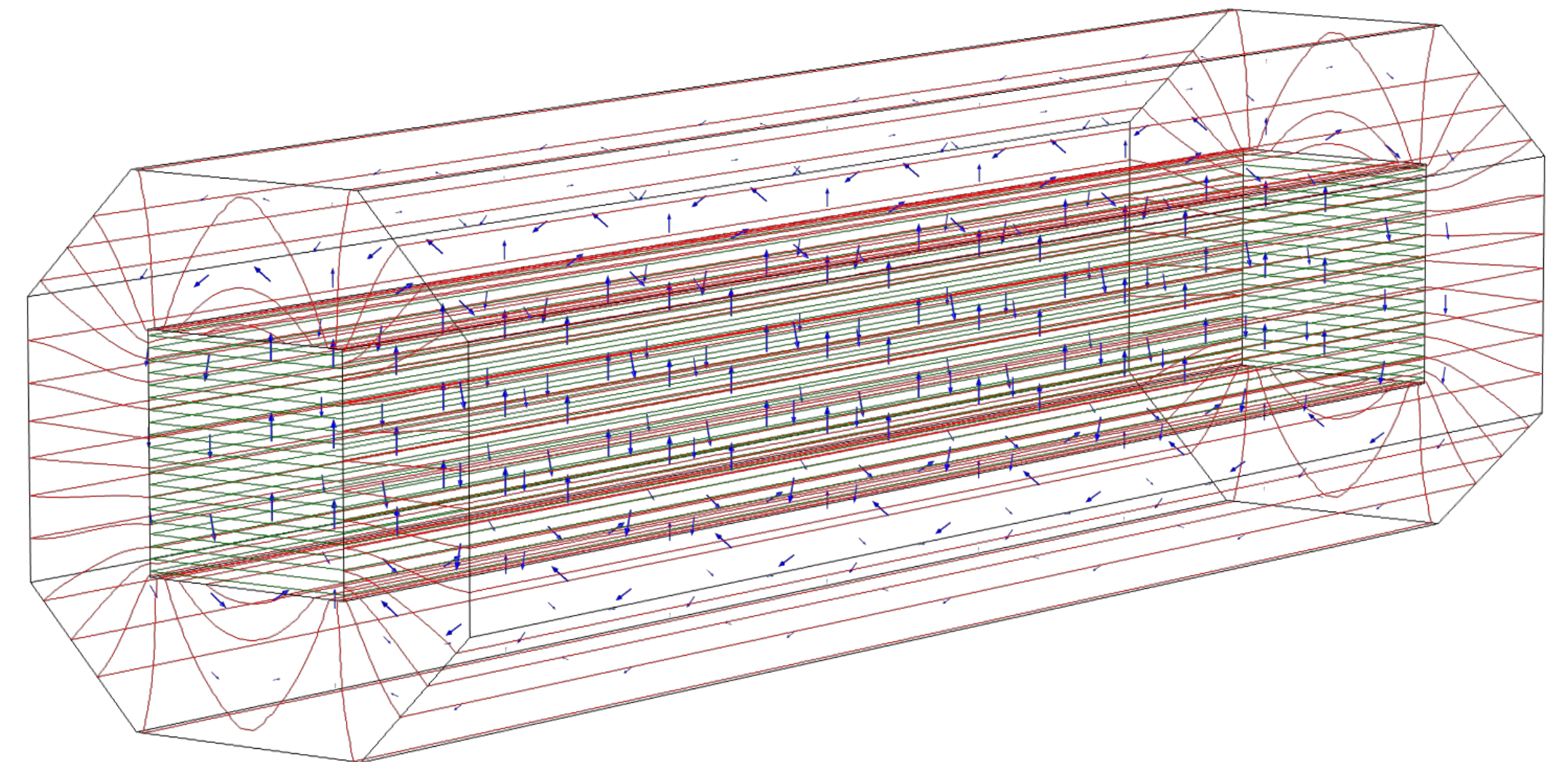so we can express the magnetic field strength as

$$\vec{H} = -\nabla \varphi.$$

From Gauss's law

$$\nabla \cdot \mu \vec{H} = 0,$$

and therefore

$$\nabla^2 \varphi = 0.$$

$\vec{B}$

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φ_1

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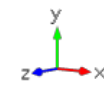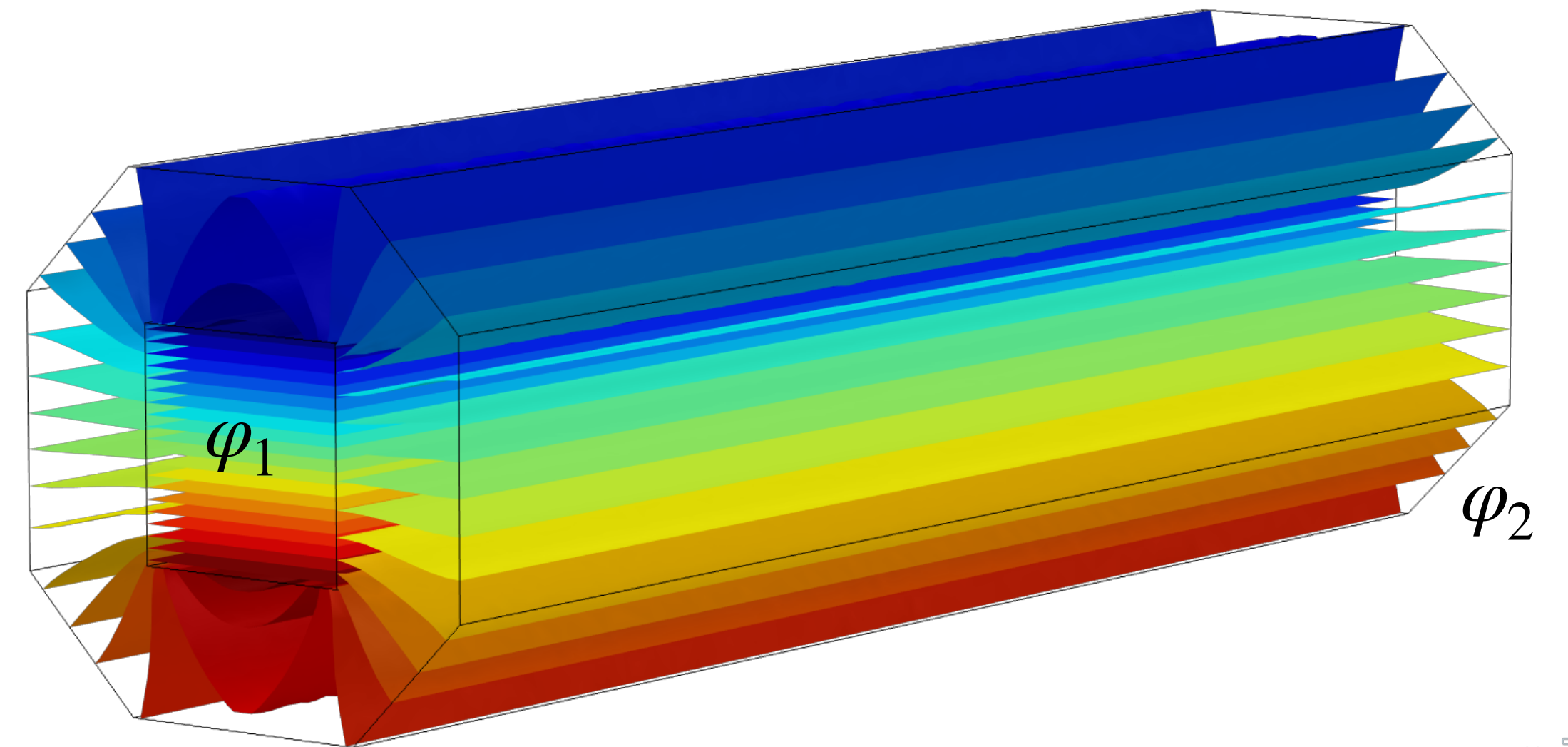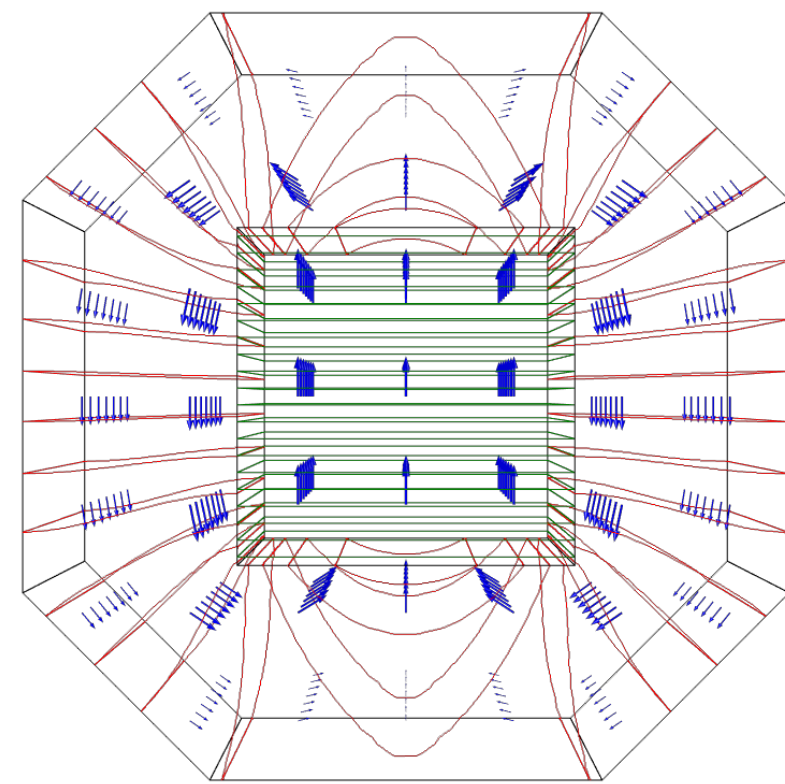so we can express the magnetic field strength as

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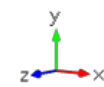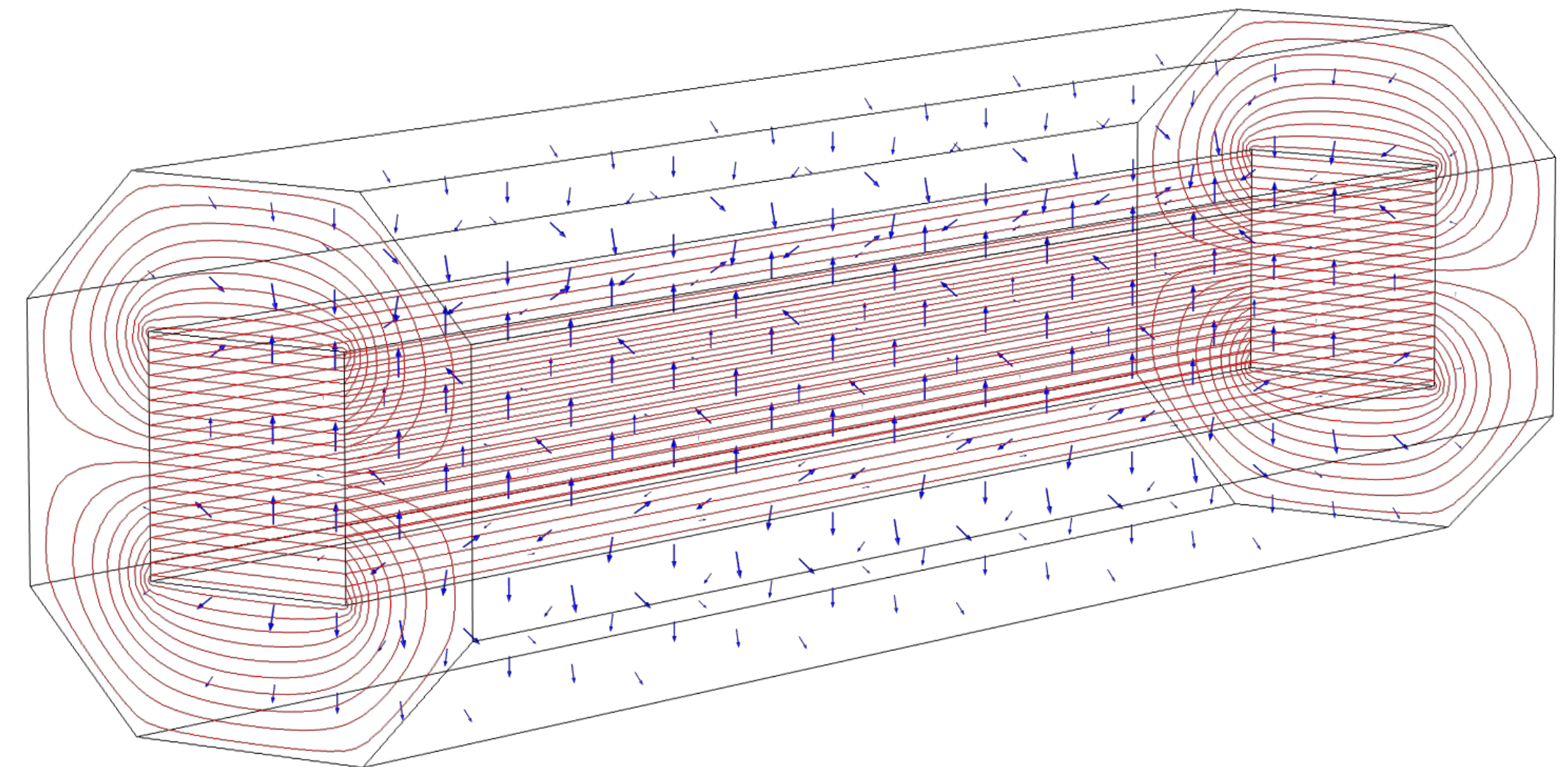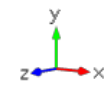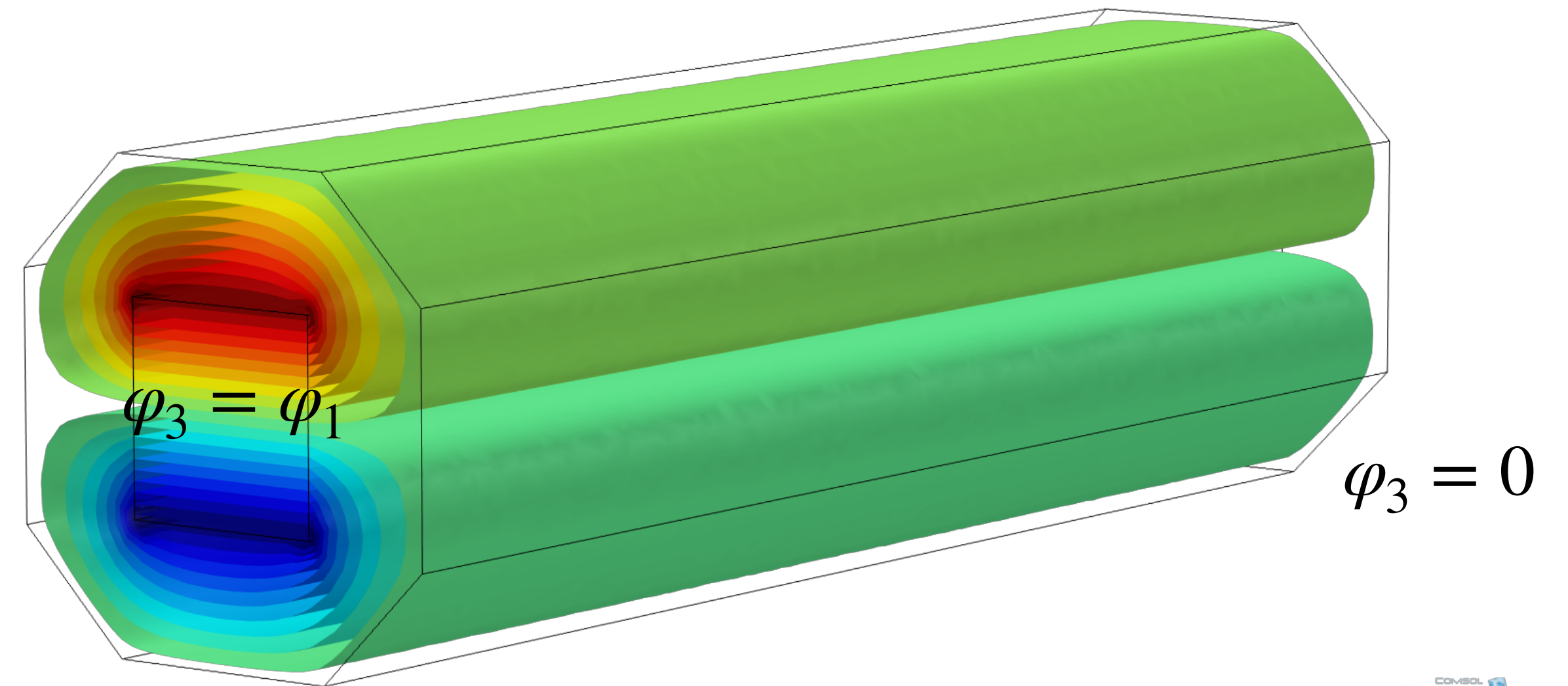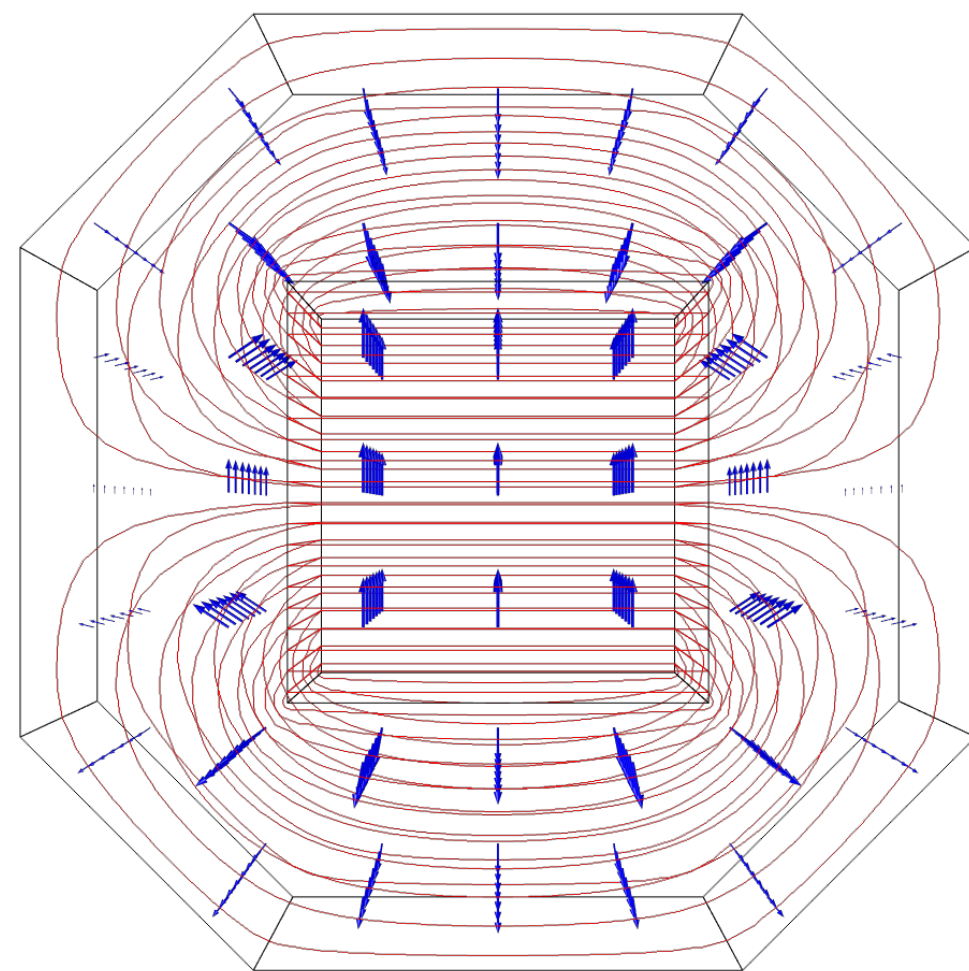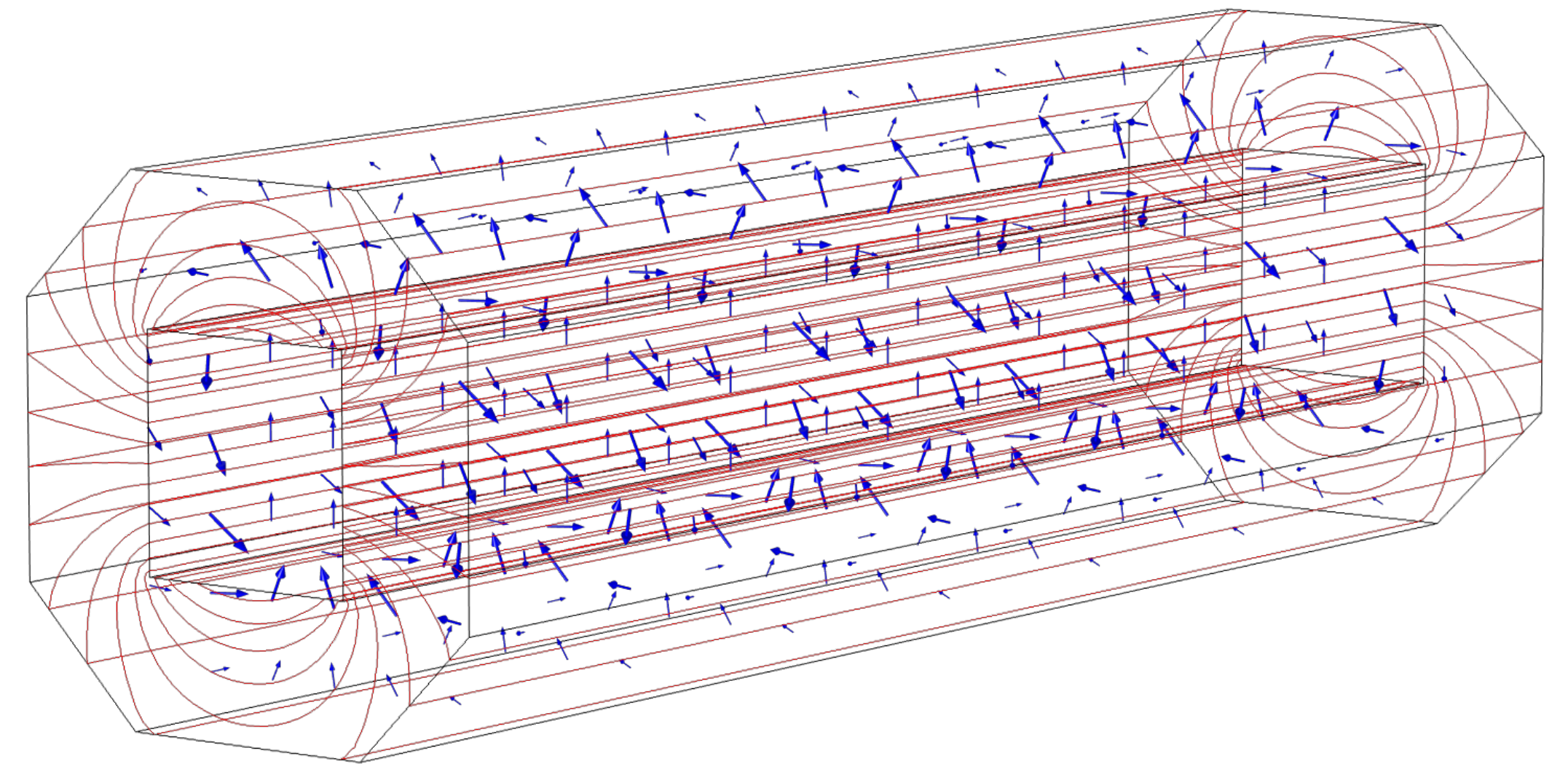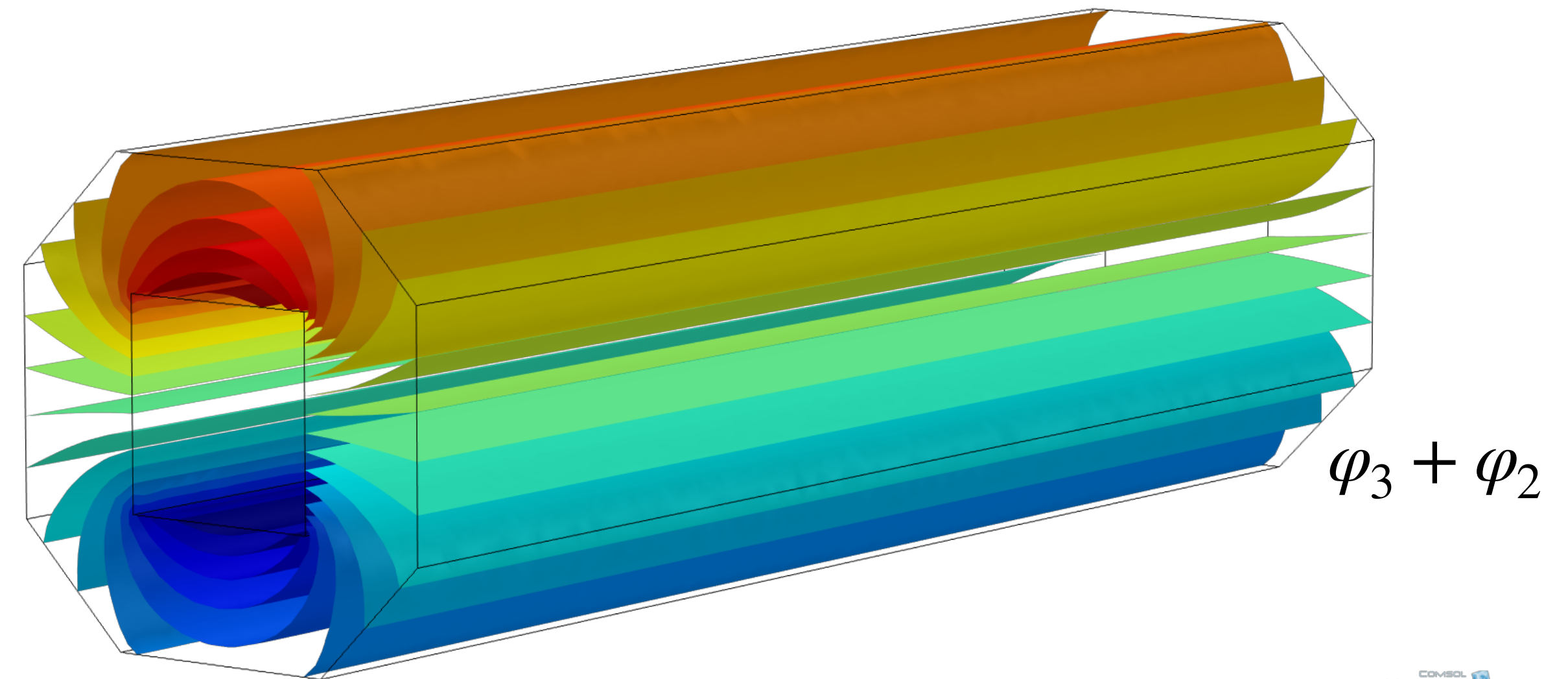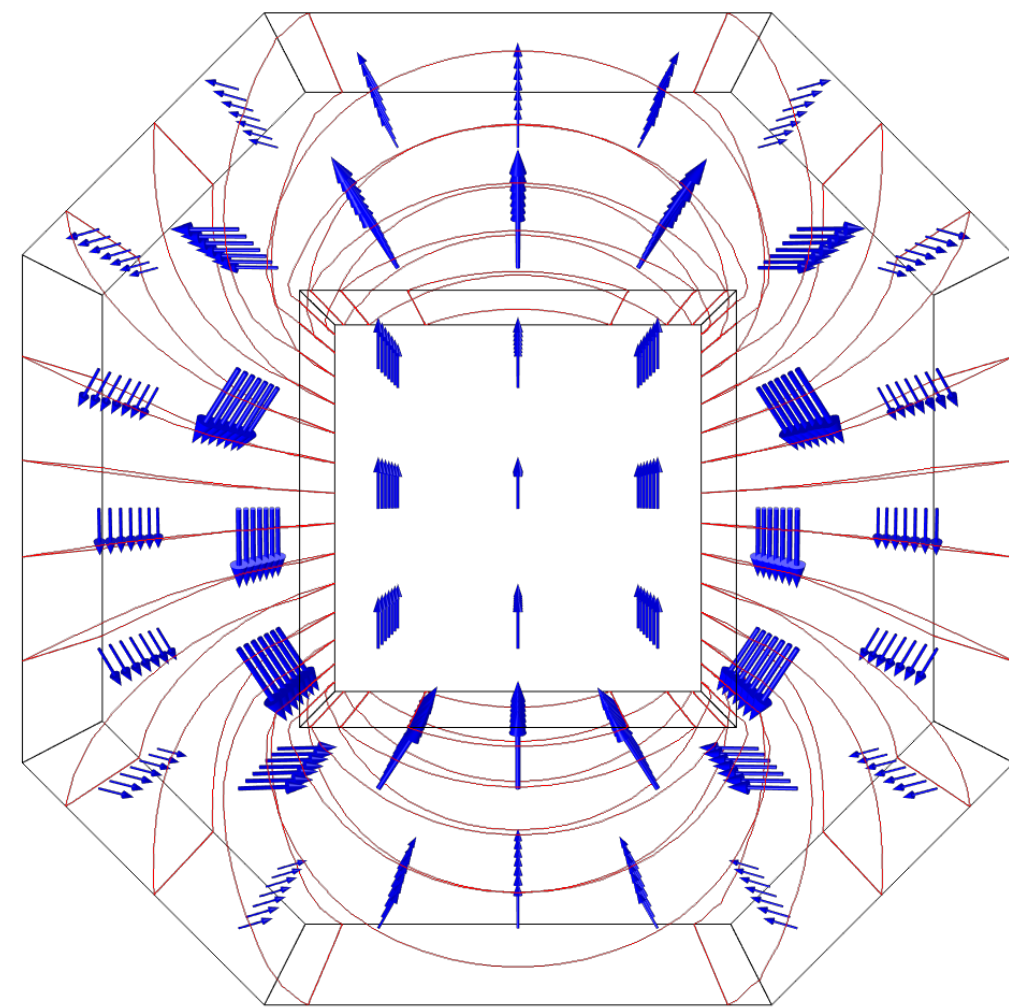so we can express the magnetic field strength as

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$\varphi_3 = \varphi_1$

$\varphi_3 = 0$

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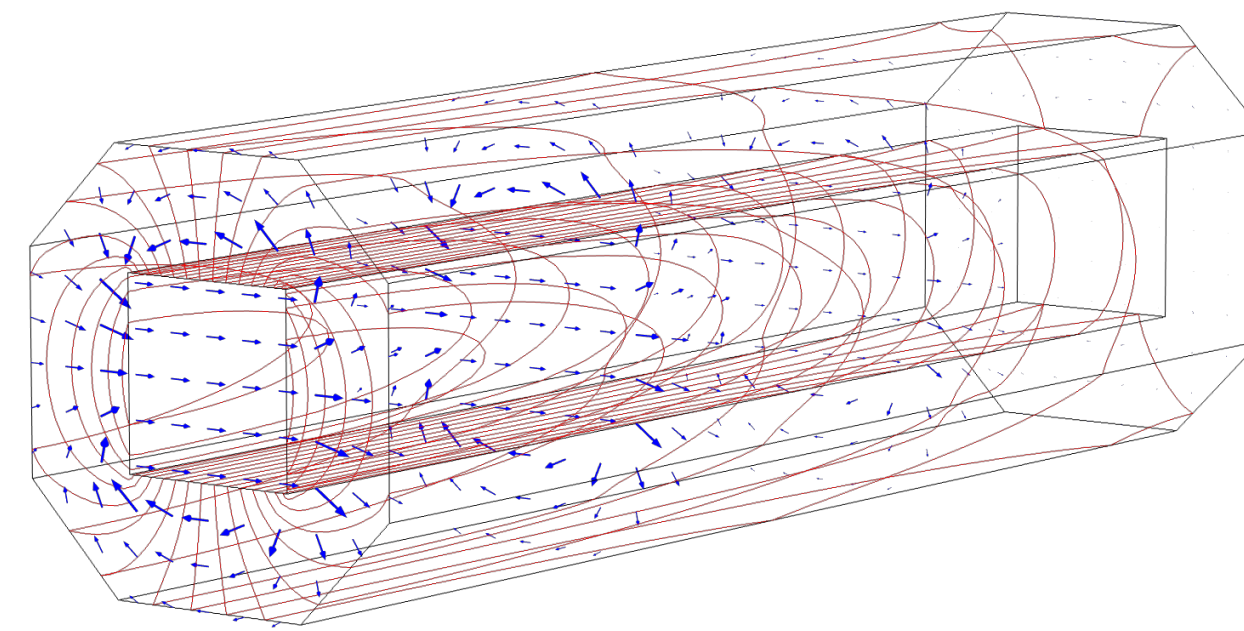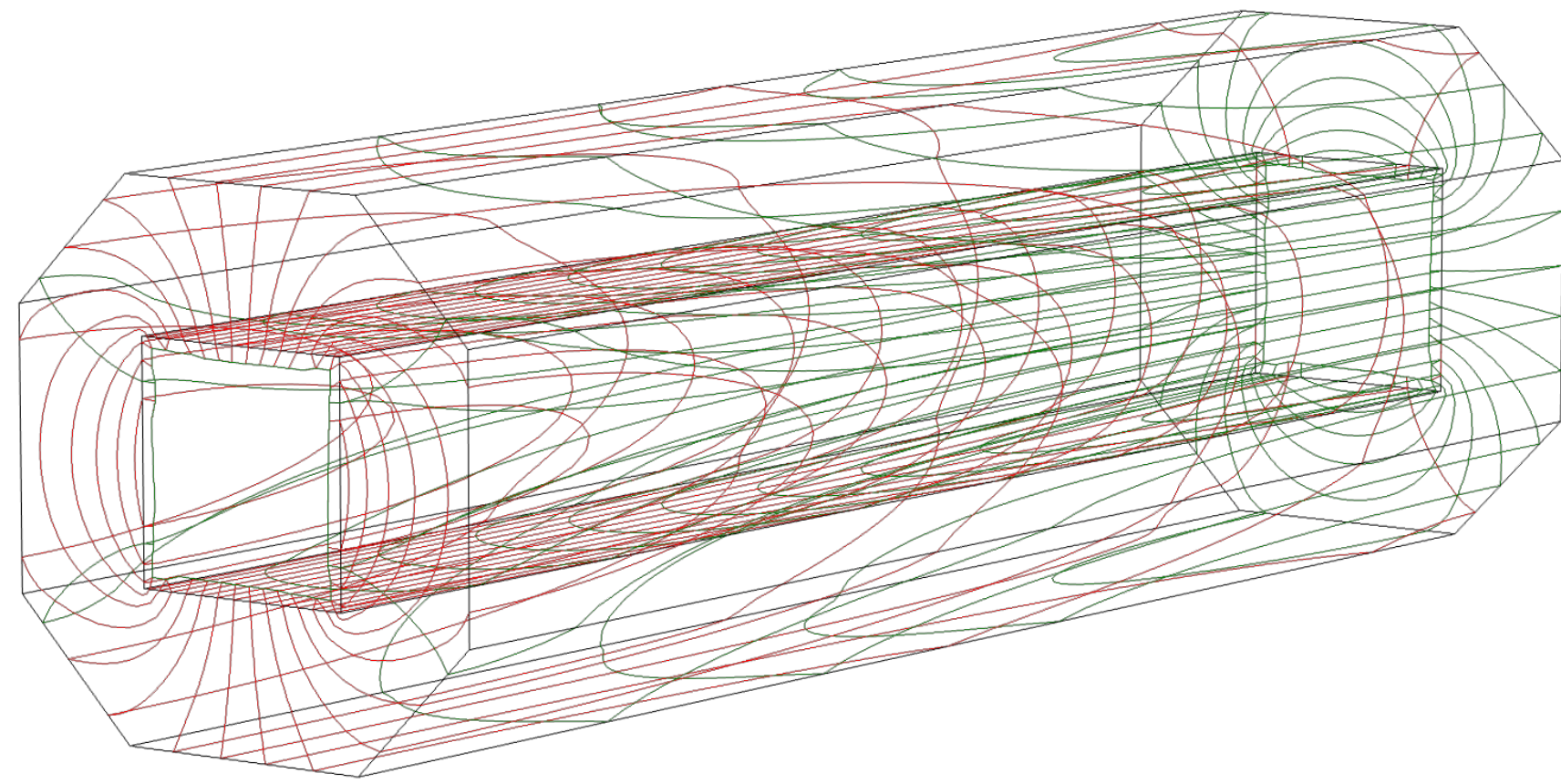
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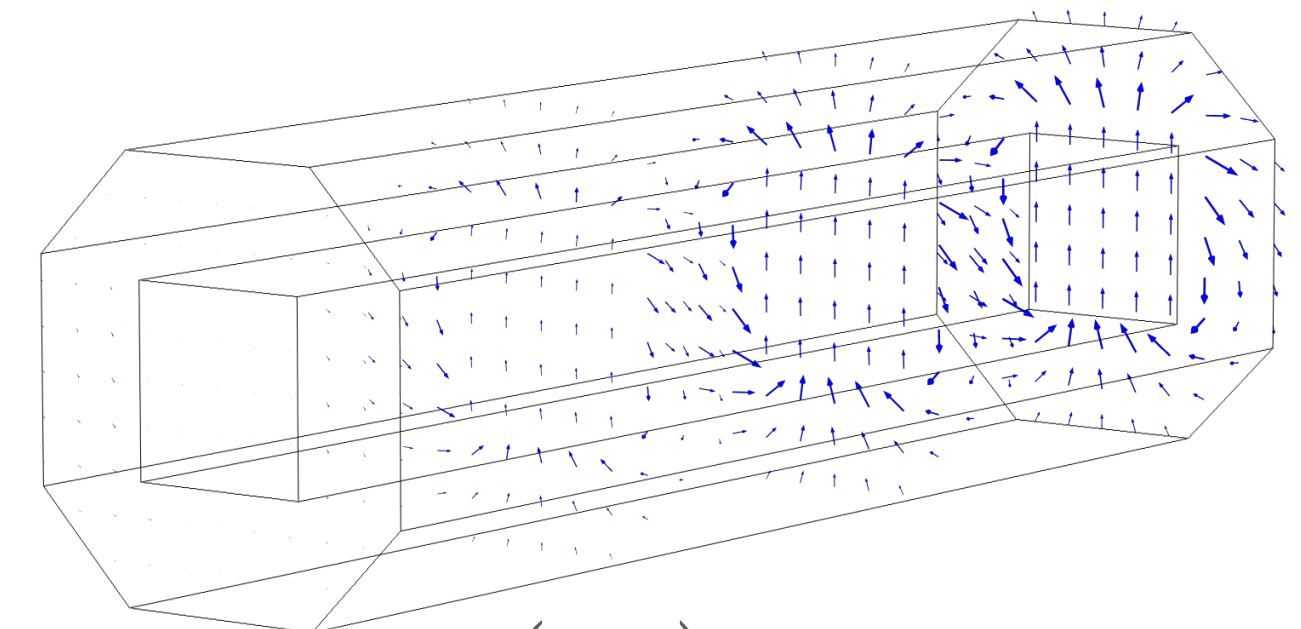
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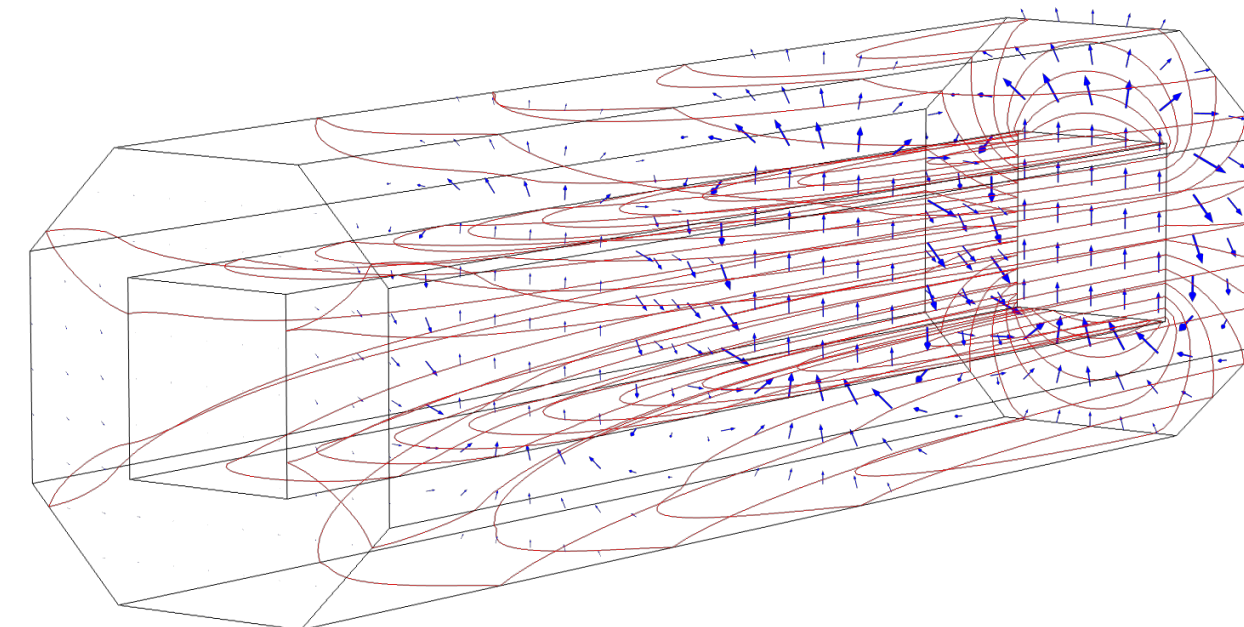
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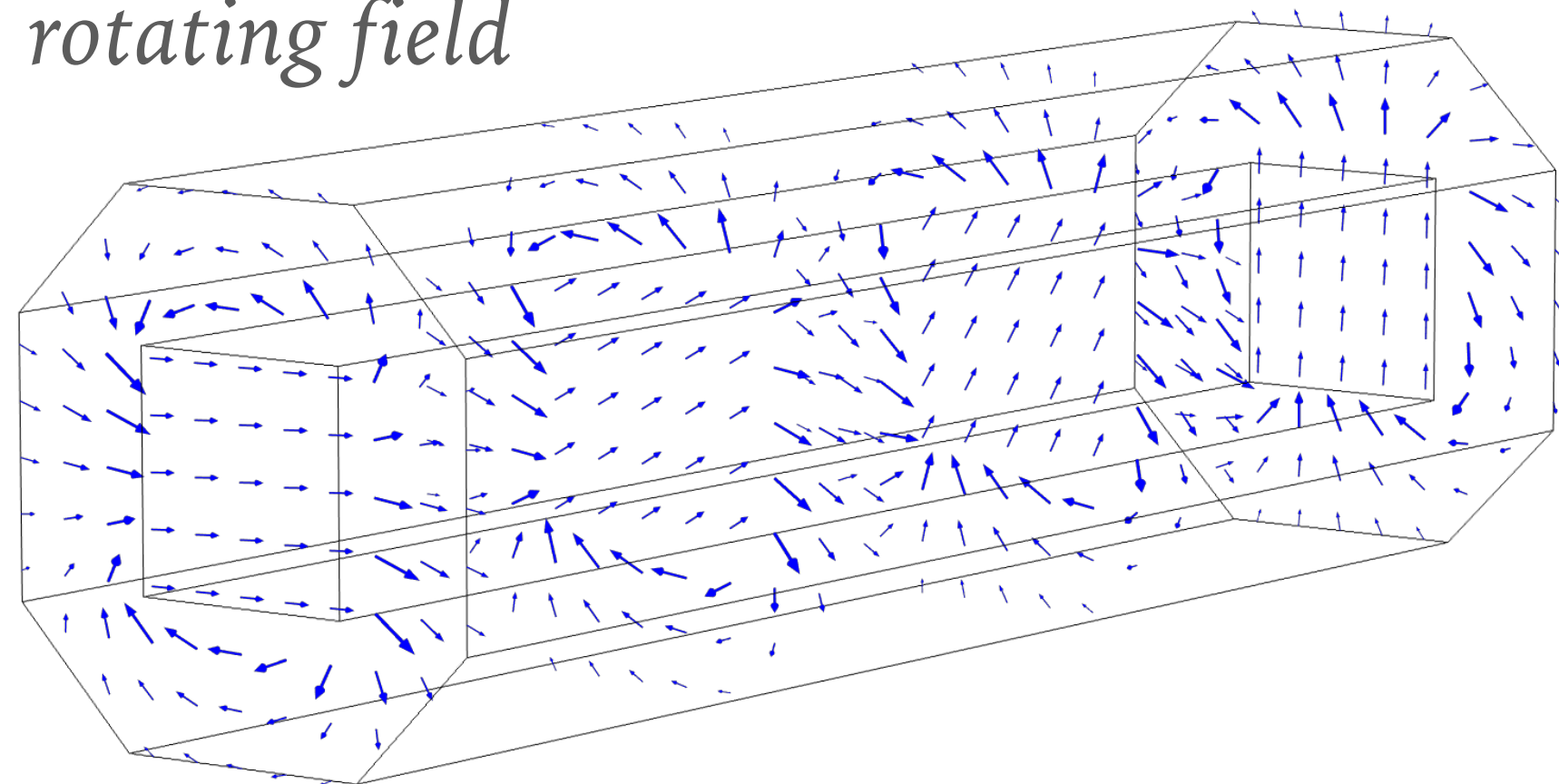
$$\varphi_3 + \varphi_2$$
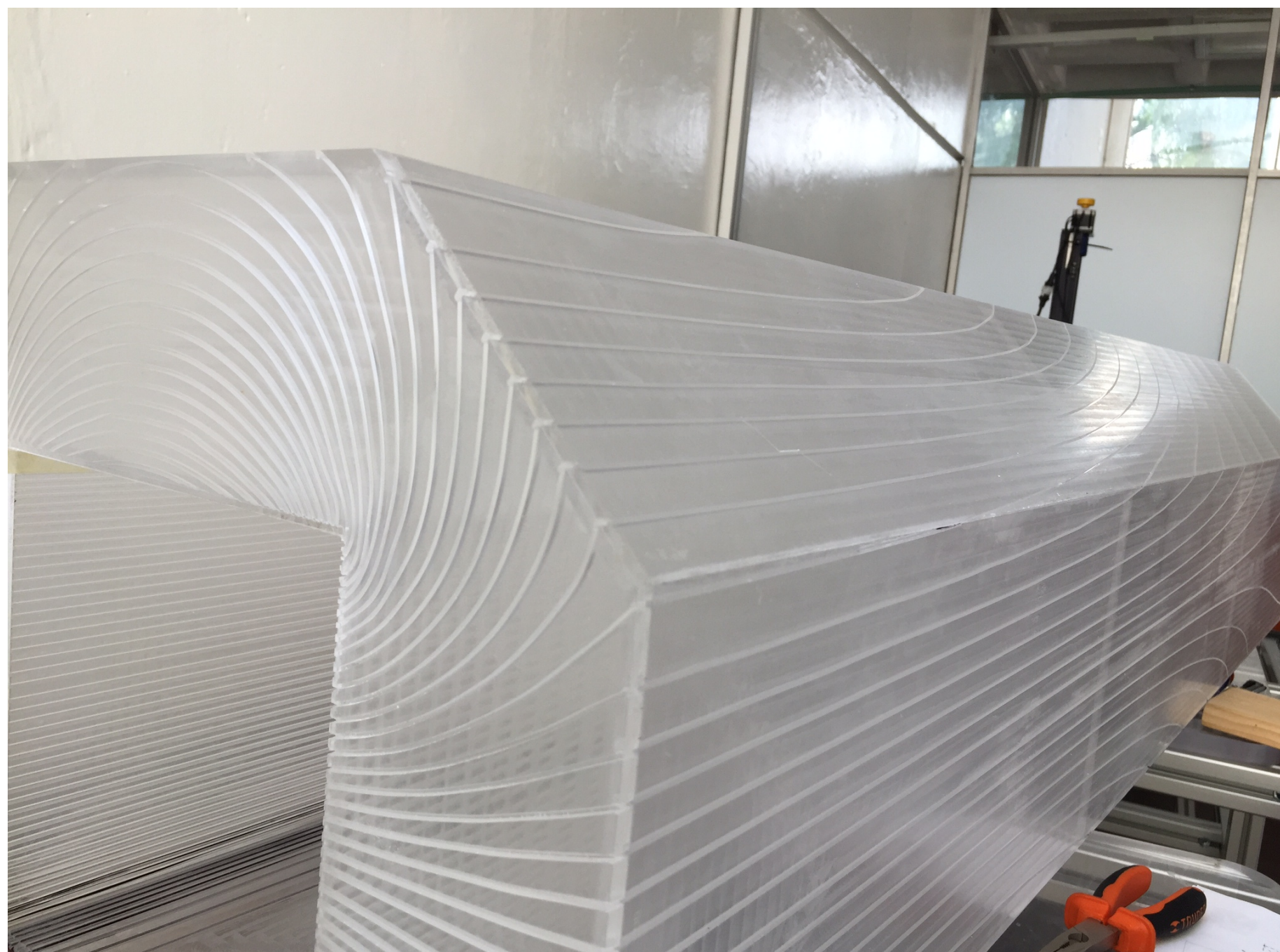
CUSTOM TAPERED MAGNETIC FIELDS
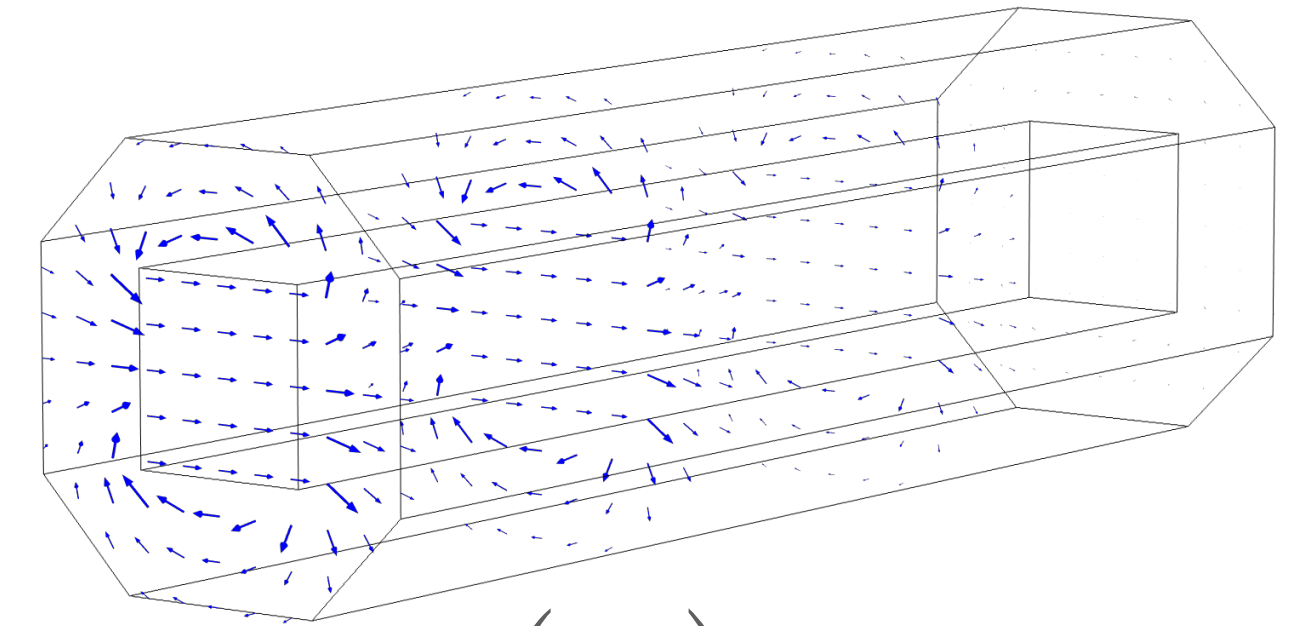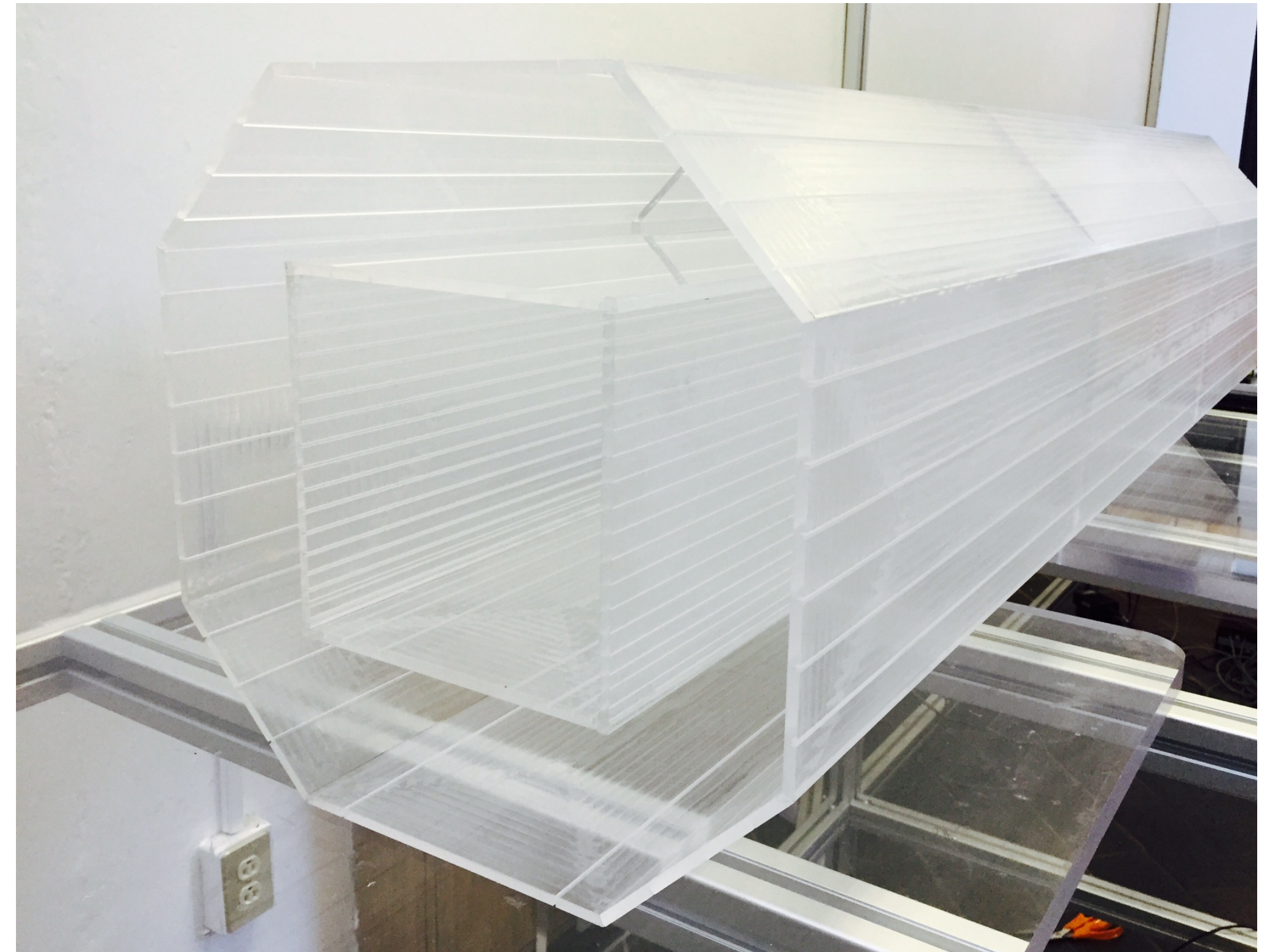

$$\cos\left(\frac{\pi z}{2L}\right)$$

rotating field
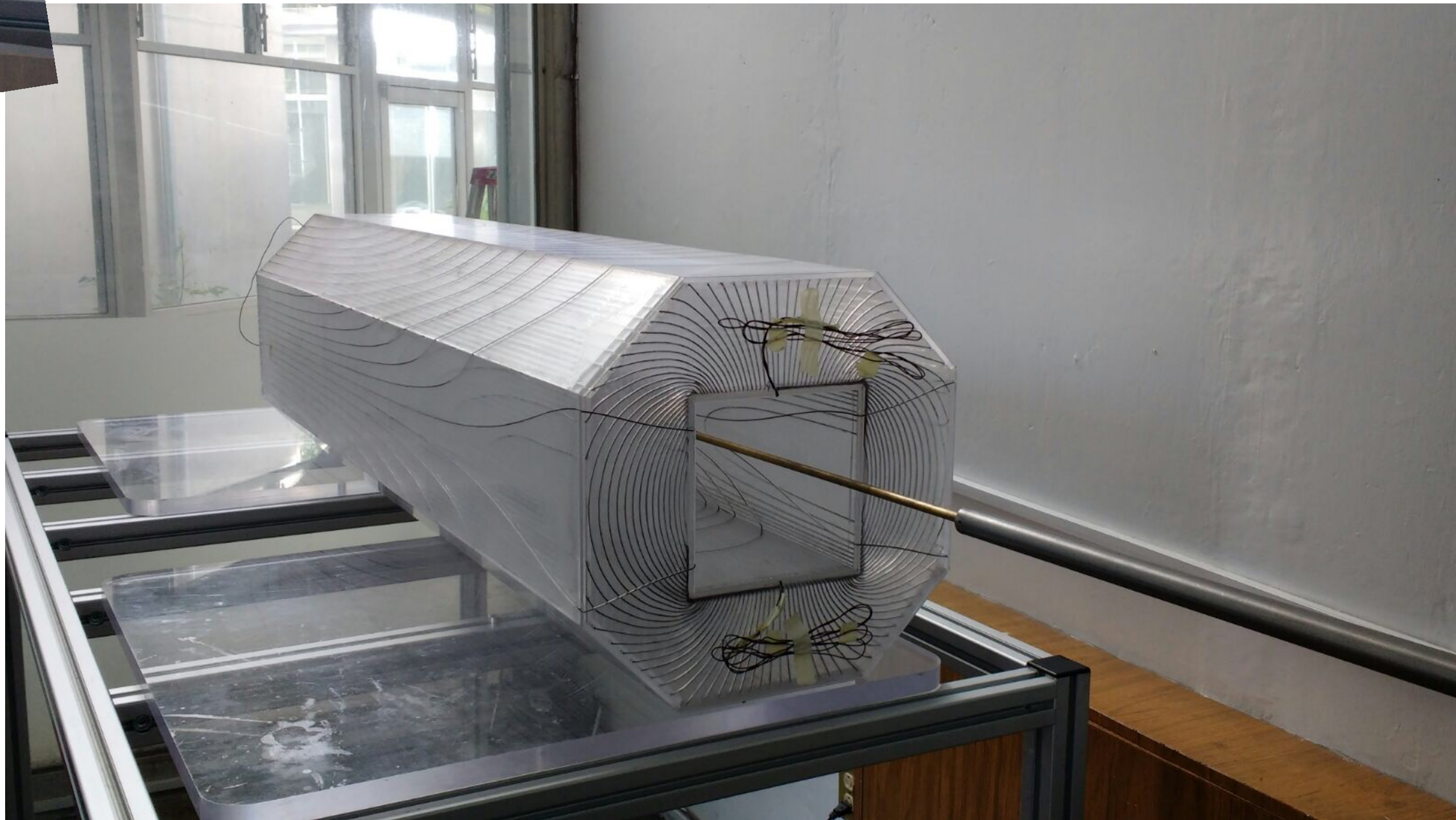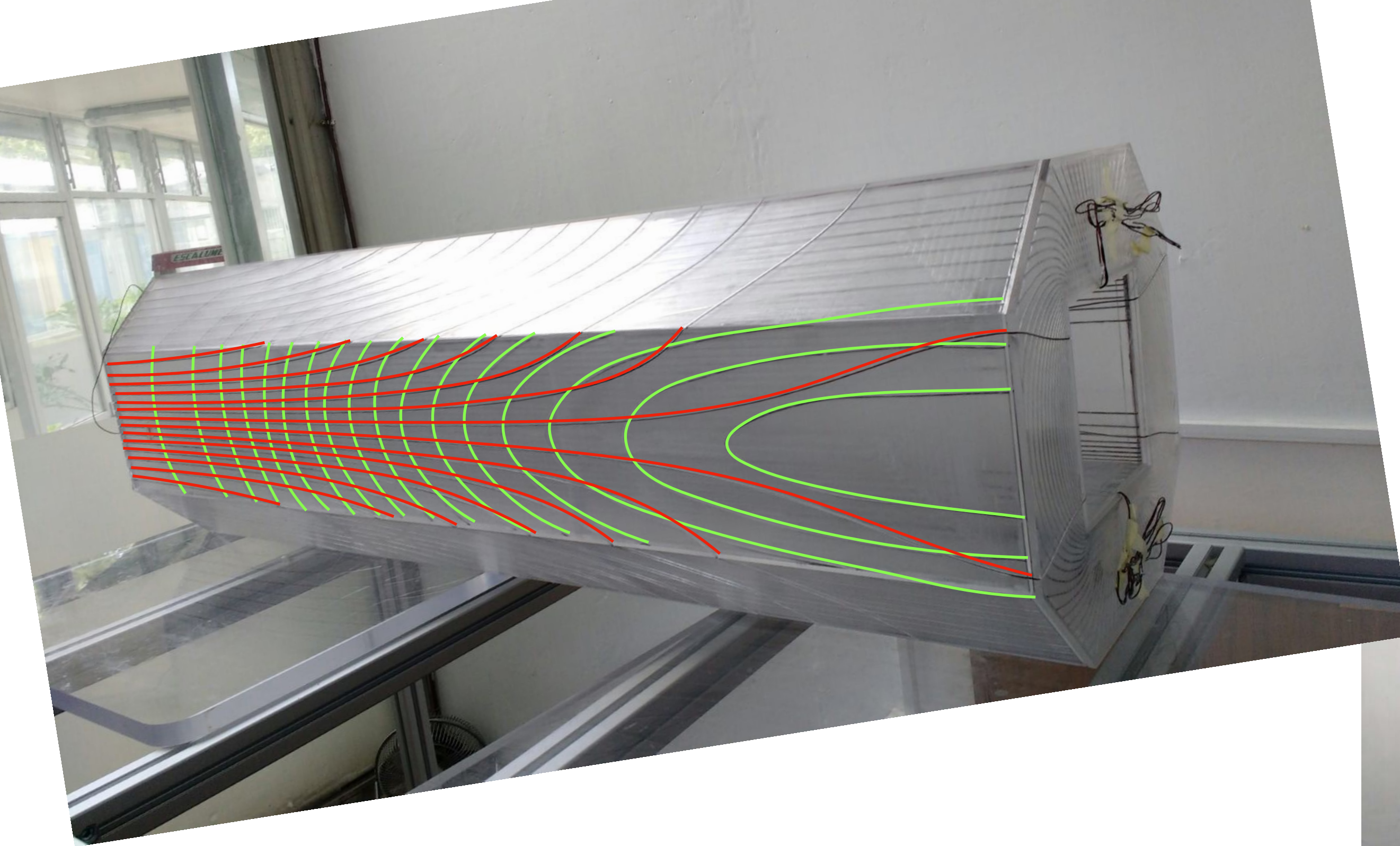
$$\sin\left(\frac{\pi z}{2L}\right)$$

➤ Hollow structure with 5 mm thick acrylic walls

➤ CNC-machined groves for gauge-18 wire following current paths
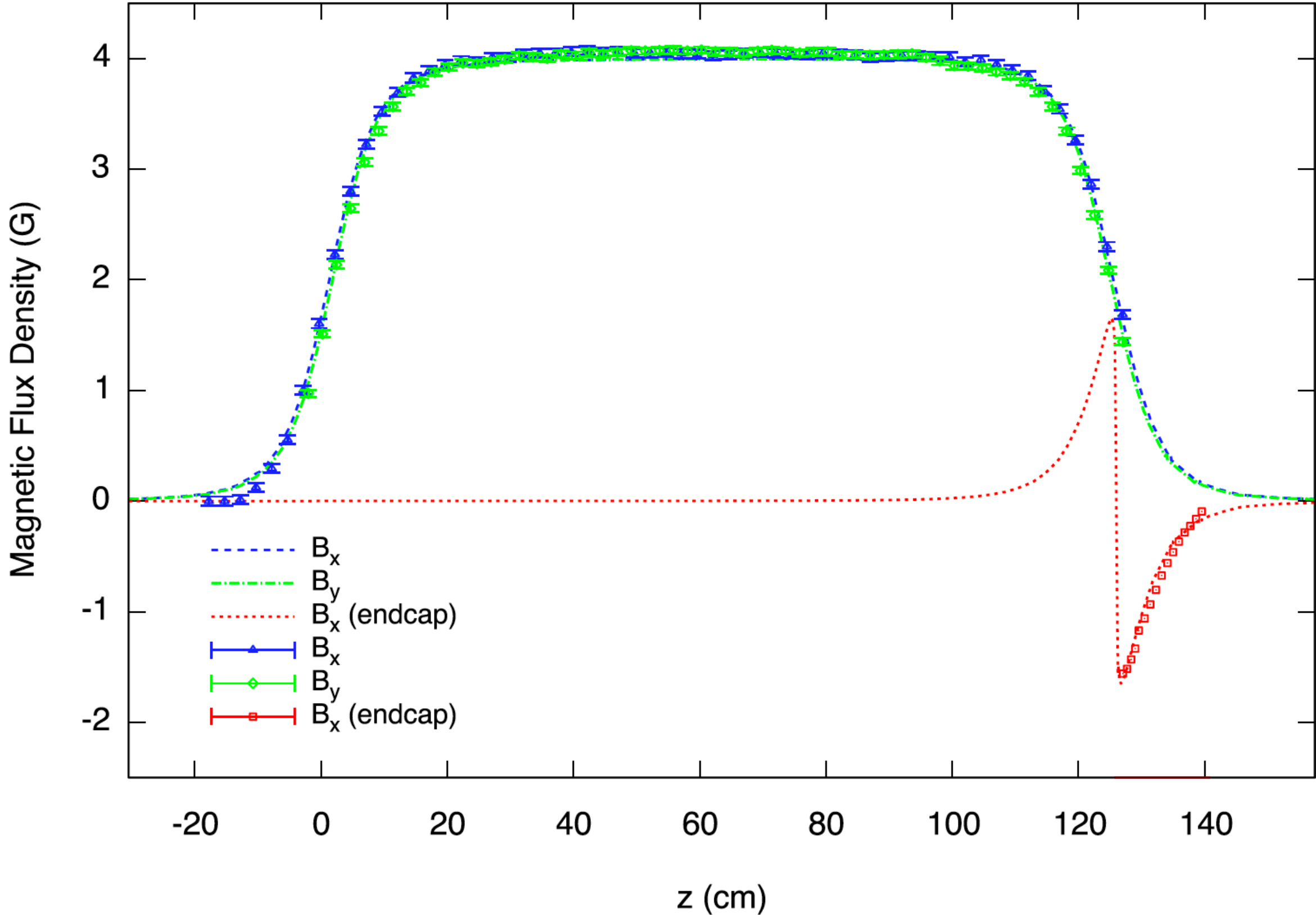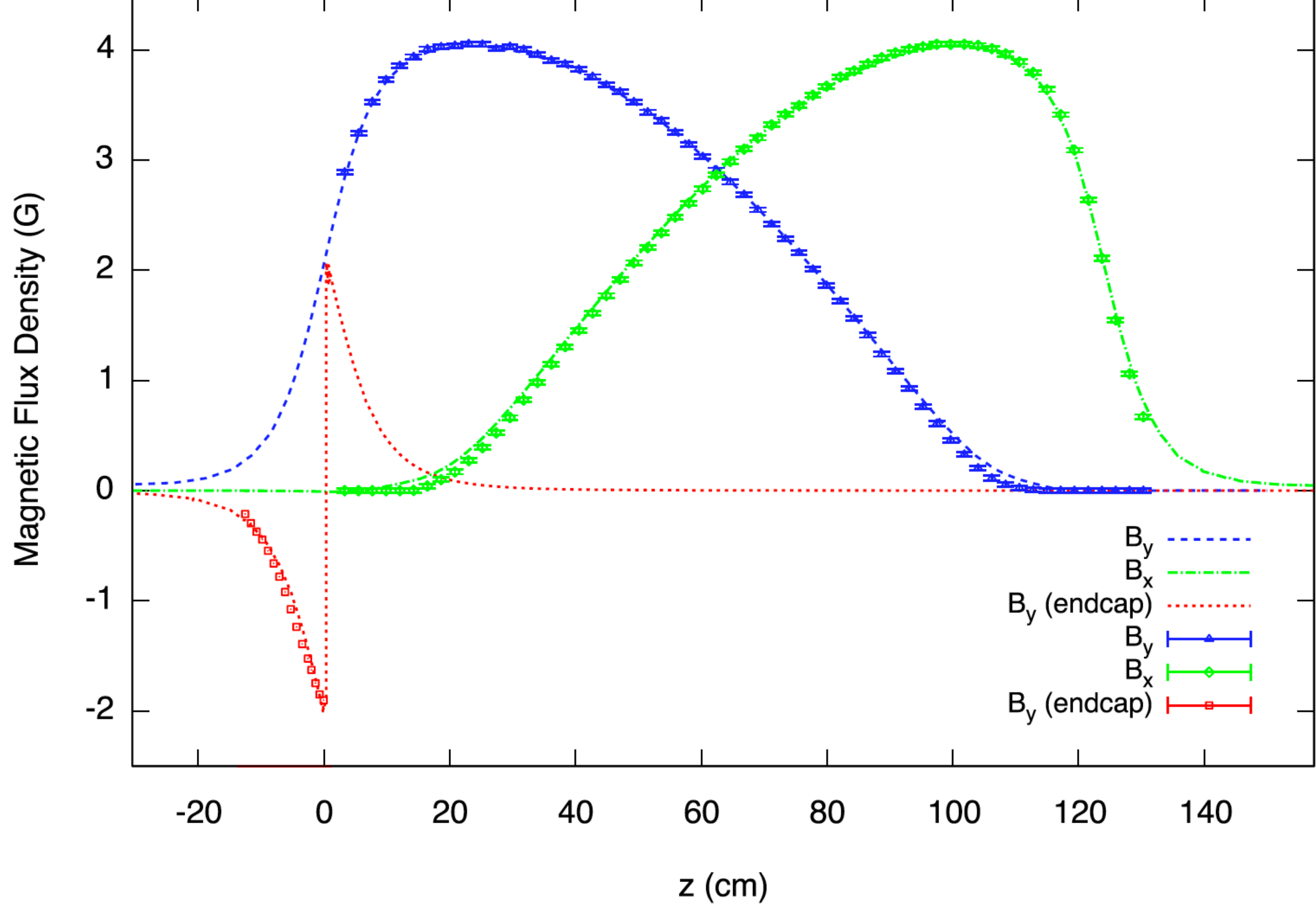
➤ Winding using gauge-18 aluminium wire and glue

➤ Second acrylic shell for perpendicular-field-component winding

CALCULATED & MEASURED FIELDS

FINAL COMMENTS

➤ The magnetic scalar potential method is a powerful tool to design coils for complicated geometry and stringent uniformity requirements

➤ CNC machining as well as 3D printing make it possible to implement complicated winding patterns using non-magnetic materias as support

➤ This technique is being applied in several neutron physics experiments like NSR, NOPTREX and nEDM

M. Maldonado-Velázquez *et al.*, NIM A 854 (2017) 127–133.